The City of New York
Department of Sanitation

2014 Annual Report on Alternative Fuel Vehicle Programs
Pursuant to Local Law 38 of 2005

2009: First Hybrid Hydraulic Collection Truck in North America

Kathryn Garcia, Commissioner
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DSNY Annual Report on Alternative Fuel Vehicle Programs Pursuant to LL38/2005

Introduction

The Department of Sanitation (DSNY) operates a sizeable fleet of trucks and other vehicles to carry out its mission of refuse and recyclables collection, street cleaning and snow removal. DSNY strives to operate the cleanest big city fleet and in 2013 won the prestigious federal EPA "Breathe Easy Leadership Award." In 2005, the City Council enacted Local Law 38 (LL38/2005), which, among other things, directs DSNY to test alternative fuel street sweeping vehicles, and report annually on its use and testing of alternative fuel vehicles.[1] This report, which is submitted to the Mayor, the Comptroller and the City Council in accordance with LL38/2005, discusses the testing, analyses and assessments of DSNY's alternative fuel sanitation collection vehicles and street sweepers, and the feasibility of incorporating new alternative fuel sanitation vehicles and technology into DSNY's fleet. It also reviews the results of DSNY's pilot program that used alternative fuel street sweeping vehicles in four sanitation districts, with one district in an area with high rates of asthma among residents.[2]

DSNY endeavors to operate its fleet in the most environmentally friendly manner, consistent with available resources, and therefore seeks to minimize emissions of concern from such operations, notably particulate matter (PM), nitrogen oxides (NOx), and greenhouse gases such as carbon dioxide.[3] New York City's air quality has improved and in 2013 met federal standards for fine particulate matter ($PM_{2.5}$), but it remains out of compliance with standards for ozone. The USEPA proposed a new, more restrictive annual standard for $PM_{2.5}$ in June 2012, which took effect in December 2012. The new annual standard declined from 15 micrograms per cubic meter to 12 micrograms per cubic meter. Based on 2011-2013 measurements, New York City's air meets the new standard.[4] In 2010, USEPA set a new 1-hour NO_2 standard of 100 parts per billion (ppb). The form for the 1-hour NO_2 standard is the 3-year average of the 98th percentile of the annual distribution of daily maximum 1-hour average concentrations. The City's compliance with this standard has not yet been determined. The USEPA proposed a new, more restrictive annual standard for ozone in December 2014, which will likely take effect in November 2015. The new 8-hour primary standard for ozone will decline from 0.075 parts per million (ppm) to a level within the range of 0.065 to 0.070 ppm, averaged over three years.

In 2014, DSNY's fleet included 2,230 collection trucks, 450 street sweepers, 365 salt/sand spreaders, 298 front end loaders and 2,360 various other support vehicles. Based on Fiscal Year 2014 figures, the entire diesel fleet required approximately 11 million gallons of diesel fuel and traveled approximately 19 million miles. On average, a standard DSNY collection truck travels approximately 6,900 miles, a DSNY dual-bin recycling collection truck:

[1] NYC Administrative Code § 24-163.2(c)(1) & (2).
[2] This pilot was required by LL38/2005. Id.
[3] While not known to cause asthma, PM, especially fine PM 2.5 microns in diameter or smaller ($PM_{2.5}$) is associated with increased respiratory symptoms, while NOx can be a precursor in the formation of ground-level ozone (regional smog) which is associated with exacerbation of asthma-related symptoms. *Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements*, 66 Federal Register at 5012 (Jan. 18, 2001); "Public Health" chapter in *New York City Comprehensive Solid Waste Management Plan Final Environmental Impact Statement* (April 2005).
[4] The annual PM2.5 NAAQS is the 3-year average annual mean concentration.

9,000 miles, and a DSNY street sweeper: 3,400 miles. As discussed below, thanks to new technologies DSNY has achieved great success in minimizing emissions of PM and NOx from its fleet.

This report includes the total number of alternative fuel "sanitation vehicles" owned or operated by DSNY by type of alternative fuel used, discusses the notable advances in DSNY's clean diesel fleet, and provides information regarding DSNY efforts to further incorporate alternative fuel vehicles into its fleet. "Sanitation vehicles" are defined by LL38/2005 as vehicles used by DSNY "for street cleaning purposes or for the collection of solid waste or recyclable materials."[5]

Dramatic Improvements in DSNY's Fleet Emissions

DSNY's fleet is already achieving an estimated *90% reduction in PM and 81% reduction in NOx emissions* fleet-wide compared with DSNY's heavy duty diesel fleet in 2005, while the newest trucks achieve *98% reductions* in each pollutant as compared with pre-1988 diesel engines.[6] In addition, DSNY has cut its light duty fleet fuel use and emissions in half since 2005.

ULSD Fuel, New Vehicle Standards, Diesel Particulate Filters, and Retrofits

Currently all of the Department's light, medium and heavy-duty diesel vehicles utilize the industry's latest computer-controlled and regulated clean-diesel engines for their respective engine model years. DSNY has gone even further: its Clean Fleet Program of testing and development of state-of-the-art technology and alternative fuels helped pioneer the improvements in heavy duty diesel emissions that are now taking place nationwide. This Program includes obtaining research grants, partnering with industry to test vehicles under real world conditions, and operating a vehicle testing facility for heavy duty trucks.

- The Department pioneered the use of ultra-low sulfur diesel fuel (ULSD)—limited to 15 parts per million (ppm) of sulfur—in July of 2001 in certain districts and expanded its use to its entire fleet in 2004 in advance of the USEPA June 2006 nationwide ULSD mandate. The new standard represents a *reduction of 97%* from the previous low sulfur standard for on-road diesel fuel of 500 ppm that took effect in 1993. Prior to 1993, the average sulfur content for on-road diesel fuel was 2500 ppm.

- ULSD allowed DSNY to expand its use of various advanced emission-control after-treatment technologies, such as diesel particulate filters and diesel oxidation catalysts. Previously, higher sulfur content fuel would have clogged these devices. These controls reduce particulate matter by 90% or better, as verified in DSNY testing.

- Since mid-2006, all of DSNY's new diesel truck purchases have met the stringent 2007 USEPA new-truck standards limiting particulate matter to 0.01 grams per brake

[5] NYC Admin. Code § 24-163.2(a)(6).
[6] Reduction in non-methane hydrocarbons is comparable, with 2012 standard of 0.14 g/bhp-hr, down from 0.5 g/bhp-hr in 2006 and 1.3 g/bhp-hr in 2003. For NOx, DSNY collection trucks have now achieved a 82% reduction and mechanical brooms have achieved a 80% reduction from their respective 2005 levels.

horsepower-hour (g/bhp-hr), *a reduction of 90% from the 2006 model year limit of 0.1 g/bhp-hr*.[7] As of 2010 NOx is limited to 0.2 g/bhp-hr, compared to 2.0 g/bhp-hr in the 2006 model year and 4.0 g/bhp-hr in the 2003 model year.

- To address the legacy of emissions from older trucks, DSNY mechanics have been installing Best Available Retrofit Technology (BART) devices such as particulate filters on pre-2007 trucks, as mandated by LL39/2005. These devices achieve reductions of up to 90% in PM and up to 25% in NOx. Including both factory-installed equipment and retrofits, by January 1, 2015 DSNY had particulate filters on 353 diesel-powered street sweepers and 2,185 collection vehicles. By July 1, 2012, all of DSNY's pre-2007 diesel collection truck fleet had the required BART retrofits or similar after-market clean diesel technology. As of January 1, 2015, DSNY has approximately 20 pre-2007 non-collection truck diesel vehicles without retrofits. They, however, are slated to be replaced within the next year with clean diesel models with factory-installed controls.

Alternative Fuel Vehicles

Despite the clear success of DSNY's Clean Diesel Program in minimizing fleet emissions, DSNY believes further improvements are possible as technology advances. DSNY therefore continues an active program of testing other kinds of fuels and technologies. Under LL38/2005, "alternative fuels" include natural gas, liquefied petroleum gas, hydrogen, electricity, and any other fuel which is at least eighty-five percent, singly or in combination, methanol, ethanol, any other alcohol or ether.[8] Including collection trucks, sweepers, and light duty vehicles that are not used to collect refuse or recyclables, DSNY currently has 949 vehicles that operate on various alternative fuels, including electric and hybrid-electric vehicles.

Compressed Natural Gas (CNG)

DSNY has 49 CNG vehicles in its active heavy-duty fleet, including collection trucks and street sweepers. DSNY has no light-duty CNG vehicles.

CNG Street Sweepers

DSNY operates 5 CNG street sweepers (see Appendix 1). As explained in last year's report, DSNY has discontinued the evaluation pilot study of CNG sweepers. Since 2007 DSNY has performed evaluations and assessments on the operation and reliability of CNG street sweepers versus conventional clean diesel street sweepers equipped with BART pursuant to local law. Based on the results, clean diesel street sweepers with BART are more reliable than CNG sweepers. As discussed below, CNG sweepers no longer offer a significant emissions advantage over new Clean Diesel sweepers. Furthermore, in the late fourth quarter of 2009, Cummins

[7] 66 Fed. Reg 5001, 5005 (Jan. 18, 2001). By comparison, the 1990 federal standard for particulate matter for heavy duty diesel highway engines was 0.60 g/bhp-hr. NOx standards have been reduced over time from 10.7 g/bhp-hr in 1988 to 0.2 g/bhp-hr starting in 2007, with a phase-in allowed until 2010, yielding an effective limit of 1.2 g/bhp-hr for 2007-2009 model years.

[8] NYC Administrative Code § 24-163.1(a)(1). Other types of fuels, such as B5 Biodiesel, do not qualify as alternative fuels.

announced that it would no longer offer the current CNG engine for street sweepers because it does not meet the USEPA 2010 air emission standard for NOx. No other manufacturer makes a CNG engine of the size needed for DSNY's street sweepers. As DSNY has no viable option for new CNG street sweepers, DSNY ended the evaluation pilot study of CNG sweepers. The 5 CNG sweepers in the fleet will continue in service until they reach the end of their operational life of approximately 5 years.

Currently, Cummins is developing a 6.7 Liter CNG engine (ISB Gas). This engine is applicable to the CNG street sweeper and will be available in 2016, at which time DSNY will assess whether to purchase additional CNG sweepers.

CNG Collection Trucks

DSNY currently owns 44 dedicated CNG sanitation collection trucks (see Appendix 2). DSNY phased out its older fleet (2001-2003 vintage) of CNG collection trucks that were problematic. CNG-fueled trucks are longer than conventional sanitation vehicles, making it more difficult to access certain narrower streets because of their wider turning radius. In Calendar Year 2008, DSNY put into service 10 new CNG collection trucks from Crane Carrier Corporation equipped with the new generation of the Cummins ISL-gas CNG engines to replace 10 of the oldest CNG trucks in the fleet. In Calendar Year 2009, DSNY put into service one front-loading Crane Carrier Corporation CNG collection truck equipped with a Cummins ISL-gas CNG engine. Also in Calendar Year 2009, DSNY ordered 10 additional CNG trucks from Crane Carrier Corporation, which were delivered in November/December 2009. In order to address the repeated failed cold starts of the fleet of Crane Carrier CNG trucks, at DSNY's request Cummins made improvements to the engine calibration software. With the problem corrected, DSNY formally added the last 10 Crane Carrier CNG trucks to the fleet in the third quarter of Calendar Year 2010. The cold-weather operation of the newest CNG trucks with the Cummins ISL-Gas CNG engines so far has been satisfactory. In Calendar Year 2013, DSNY ordered and received delivery of 23 additional CNG trucks from Mack Trucks, equipped with a Cummins ISL-gas CNG engine. DSNY put these 23 additional trucks into service in January 2014.

Hybrid-Hydraulic CNG Collection Truck

In an agreement with National Grid, DSNY also put into service one hybrid-hydraulic CNG collection truck in October 2010. The reliability of this truck so far has been acceptable; testing is on-going. Hybrid-hydraulic technology, which can be employed with any kind of fuel, is further discussed below.

CNG Fueling Facility

Under a federal consent order, DSNY built a fully-operational, heavy-duty vehicle CNG fueling station in Woodside, Queens, at a cost of approximately $2,950,000.[9] This station went into service in May 2007 and provides shorter fueling times than other CNG fueling facilities.

[9] This project was undertaken as part of a settlement of a lawsuit brought against the City and DSNY by the United States for violations of the Clean Air Act. *United States v. City of New York*, 99 Civ. 2207 (LAK) (S.D.N.Y.).

Discussion: CNG vs. Clean Diesel

From an operational perspective, preliminary results on testing the latest generation of CNG collection trucks indicate they have improved in reliability from earlier model CNG trucks, but they are still not as reliable as clean diesel trucks. From an air emissions/public health perspective, CNG no longer offers a significant advantage over clean diesel. As a result of the use of ULSD and new emissions control technologies, heavy duty diesel truck particulate matter emissions are very low, and are comparable to those from CNG-fueled heavy duty vehicles. Nitrogen oxide emissions from the two technologies are also comparable; with CNG truck NOx emissions slightly lower than the NOx emissions from diesel trucks with advanced after-treatment technologies.[10] On the other hand, greenhouse gas emissions from CNG trucks are reportedly 20-23% lower than those from diesel trucks.[11] It has been noted that CNG trucks are somewhat quieter than diesel trucks,[12] but compaction noise from CNG collection trucks and diesel collection trucks are generally comparable. CNG trucks emit more methane (a greenhouse gas) and more carbon monoxide than conventional clean diesel vehicles.[13]

The prior economic advantage of CNG (due to recoverable domestic reserves) has diminished and diesel prices have now fallen below current CNG prices; however, due to the historical volatility of the price of crude oil, there remains a great deal of uncertainty as to the future price of diesel fuel. As of February 2, 2015, a gallon of diesel fuel cost $1.84 while a gallon-equivalent of CNG cost approximately $2.40; whereas one year ago in January 2014, a gallon of diesel fuel cost $3.29 while a gallon-equivalent of CNG cost approximately $2.31. CNG-fueled vehicles have lower fuel efficiency and a CNG-fueled collection truck costs approximately $35,000 more per unit than a diesel collection truck. For a collection truck that drives 6900 miles in a year at an average 2.5 miles per gallon, the annual diesel fuel cost at $1.84/gal is $5,078 (versus last year's annual cost of $9,080); the equivalent in CNG fuel at $2.40/gal eq. is $6,624 (versus last year's annual cost of $6,375). Further, DSNY has only one CNG fueling station for its 59 district garages, and the handful of private CNG filling stations in the City are generally not equipped for rapid filling of heavy duty trucks. Thus any move to significantly expand DSNY's CNG truck fleet would require additional investment in capital funds to build CNG fueling infrastructure and in facility modifications as required by the New York City Building Code.

E85 Ethanol Blend Vehicles

Local Law 38 of 2005 prohibits the purchase of new bi-fuel vehicles, such as vehicles capable of running on E85. DSNY has discontinued the use of E85 in its light-duty fleet. E85 is a fuel blend of 85% corn-based ethanol (which is renewable) and 15% gasoline. It requires

[10] Ayala, *et al.*, *CNG and Diesel Transit Bus Emissions in Review* (August 2003); Ayala, *et al.*, *Diesel and CNG Heavy-Duty Transit Bus Emissions over Multiple Driving Schedules: Regulated Pollutants and Project Overview* (Society of Automotive Engineers, 2002).
[11] Peter Hildebrandt, "NGVs & Onboard Equipment," *MSW Management*, March/April 2011, *NGV Fleet Manager Supplement*, at 14 (citing figures from Clean Vehicle Education Foundation).
[12] INFORM, Inc., *Greening Garbage Trucks: New Technologies for Cleaner Air* (2003).
[13] DSNY Commercial Waste Management Study, Vol. VI, at ES-5, 23 (March 2004); Ayala, *et al.*, *Diesel and CNG Heavy-Duty Transit Bus Emissions over Multiple Driving Schedules* (indicating CNG buses emit more carbon monoxide than retrofitted diesel buses).

separate fuel storage tanks. DSNY vehicles capable of running on E85 consisted of bi-fuel Ford Taurus sedans and Ford Explorer sport utility vehicles. Such vehicles did not always run on E85 in practice when it was more convenient to utilize gasoline. While the operation of these vehicles using E85 was generally satisfactory, they did not achieve significant emissions savings over gasoline vehicles, although NOx emissions were somewhat lower. Fuel mileage was less than with gasoline. Greenhouse gas reductions from using E85 have not proven to be compelling, according to various studies.

Hybrid-Electric Heavy Duty Vehicles

Hybrid-Electric Sweepers

DSNY is currently testing 13 diesel-powered hybrid-electric street sweepers in eight districts (see photo above). In CY2010, DSNY put into service the "World's" first Class-7 hybrid-electric street sweeper. In CY2013 and CY2014, DSNY increased its fleet of diesel powered hybrid-electric street sweepers to thirteen. Testing is ongoing. These vehicles have the potential of even lower emissions and better fuel mileage than the latest Clean Diesel engines.

Hybrid-Electric Diesel Collection Trucks

DSNY ordered three experimental (prototype) hybrid-electric diesel trucks from Crane Carrier Corporation in 2008, which were put into service in June 2010 (see Appendix 3). This initiative was sponsored by the New York State Energy Research and Development Authority and the Hybrid Truck Users Forum. This hybrid technology has the potential to reduce fuel use and related emissions by capturing and reusing energy that is otherwise wasted during the frequent braking of collection vehicles.

Hybrid-Hydraulic Heavy Duty Vehicles

Hybrid-Hydraulic Diesel Collection Trucks

DSNY ordered two experimental (prototype) hybrid-hydraulic diesel trucks from Crane Carrier Corporation in 2008, which were put into service in October 2009 (see photo on cover and Appendix 3). This initiative was sponsored by the New York State Energy Research and Development Authority and the Hybrid Truck Users Forum. The hybrid-hydraulic diesel trucks are made with technology from Bosch Rexroth, called the Hydrostatic Regenerative Braking (HRB) System. These are the first such trucks in North America; they have also been tested in Germany. In CY2013, DSNY put into service 17 additional next-generation Bosch Rexroth hybrid-hydraulic trucks. DSNY applied for and obtained federal Congestion Mitigation and Air Quality (CMAQ) grant funds for 80% of the cost of these new purchases. Also in CY2013, DSNY successfully applied for federal CMAQ grant funding to purchase 32 additional diesel-powered hybrid-hydraulic trucks from Mack Trucks for Calendar Year 2014 delivery. Currently, DSNY has a total of 49 hybrid-hydraulic trucks in service. As noted above, this hybrid technology has the potential to reduce fuel use and related emissions by capturing and reusing energy that is otherwise wasted during the frequent braking of collection vehicles.

Thus far, the hybrid-hydraulic diesel collection trucks have outperformed the hybrid-electric diesel collection trucks, with less downtime. DSNY's testing of this first generation hybrid-hydraulic technology indicated a fuel savings of approximately 10% and reduction in greenhouse gases and a savings in brake replacement frequency and associated labor. DSNY mechanics are already familiar with servicing hydraulic technology from standard rear-loading collection trucks that have hydraulic compaction systems, which help minimize retraining needed for the new technology. The trucks were also found to result in less braking "squeal" noise than from conventional diesel collection trucks. Following successful testing in 10 European cities and New York City, the manufacturer put the hybrid-hydraulic technology into mass production in October 2010. As a result, the incremental additional cost of hybrid-hydraulic technology has dropped to $47,000 when applied to a diesel truck, compared to $35,000 for CNG trucks. Thus, for a collection truck that drives 6900 miles in a year at an average 2.5 miles per gallon, the annual diesel fuel cost at $1.84/gal is $5,078; a 10% savings in fuel amounts to approximately $507/year compared to a conventional clean diesel collection truck, assuming stable fuel costs. Vehicle emissions would likewise be reduced by approximately 10%. Additional savings are expected on maintenance costs (brakes and labor), not including capital costs.

Due to the dramatic drop in the price of diesel fuel that ultimately eliminated the potential for return on investment for hybrid-hydraulic system manufacturers in the last year, these manufacturers have discontinued production of the hybrid-hydraulic trucks. Therefore, currently DSNY has no viable option for new hybrid-hydraulic heavy duty trucks. The 52 hybrid-hydraulic collection trucks in the fleet will continue in service until they reach the end of their operational life.

Hybrid-Electric Light-Duty Vehicles

DSNY has 778 hybrid-electric light-duty vehicles, with such models as the Toyota Prius sedan and Ford Hybrid Escape sport utility vehicle (SUV). These vehicles operate on gasoline assisted by battery technology, and can recover and reuse energy captured during braking. The performance of these vehicles has been good, with significantly improved gas mileage and lower emissions than standard gasoline vehicles, despite higher initial vehicle costs than a comparably-sized gasoline model. As a result, DSNY has cut its light duty vehicle fuel use (gasoline and ethanol) in half since 2005 mainly through the use of such hybrid vehicles. In FY2012 and FY2013, DSNY purchased 16 and 136 Ford Fusion Hybrids, respectively.[14] In FY2014, DSNY purchased 24 additional Ford Fusion Hybrids, for a total of 176 Ford Fusion Hybrids. Consistent with LL38/2005, DSNY expects to increase its fleet of hybrid-electric light-duty vehicles.

Plug-In Hybrid-Electric Vehicles

Beyond the hybrid-electric light duty vehicles discussed above, DSNY anticipates that both plug-in hybrid electric vehicles (with a gasoline engine) and pure electric (battery only) vehicles have a role to play in helping the City achieve PlaNYC2030's goals of conserving energy, making local air quality the best of any big American city, and reducing the greenhouse gas emissions from City operations 30% below FY2005 levels by 2017. In FY2012 DSNY purchased and received delivery of 14 state-of-the-art plug-in hybrid-electric Chevrolet Volt sedans, which are capable of running entirely on battery power for an extended range of up to 40 miles before a gasoline engine starts up to charge the battery. DSNY purchased seven more Chevy Volts in CY2013. In FY2015 so far, DSNY purchased 11 Ford Fusion Energi Plug-in Hybrids, which are capable of running entirely on battery power for an extended range of up to 19 miles before a gasoline engine starts up to charge the battery; DSNY expects delivery in the second quarter of CY2015. In total, DSNY has 21 plug-in hybrid-electric sedans in its fleet.

Volt vs. Conventional Hybrid

The Chevrolet Volt is now a commercially available model with the same California Air Resources Board (CARB) emissions rating (Alternate Technology Partial Zero Emission Vehicle, or AT-PZEV) as the 2011 Toyota Prius. As such, both the Volt and the Prius are capable of zero emissions when running only on battery power, but the Toyota Prius battery-only range is rated by the USEPA at under one mile. As a DSNY sedan on average travels approximately 33 miles in a day, in practice a 2011 Toyota Prius will utilize its internal combustion engine and have higher direct emissions than a Volt for a DSNY shift that does not exceed 35-40 miles of driving.

The Chevrolet Volts have performed well in the field. The primary advantage of the Volt over a conventional hybrid such as the Toyota Prius or Ford Fusion Hybrid is the Volt's ability to run on pure electric battery mode for an extended range, therefore emitting fewer direct air emissions during a typical duty cycle than a conventional hybrid. According to the USEPA, a 2011 Volt gets the equivalent of 93 miles per gallon when operating in all-electric mode (MPGe), and 37 mpg when operating in gasoline mode, for an overall rating of 60 mpg. (The

[14] EPA mileage estimates for the Fusion Hybrid are 41 mpg highway and 36 mpg city.

2012 Volt has a USEPA rating of 94 miles per gallon in electric-only mode). The USEPA rated the Volt as capable of being driven an estimated 35 miles in all-electric mode. The USEPA rated the 2011 Toyota Prius as achieving 50 mpg combined/51 mpg City/48 mpg highway. If used with premium gasoline, as recommended by the manufacturer, the Volt fuel cost per gallon increases by 21 cents over regular gasoline.[15] The fuel use and emissions of a Volt will vary depending on the amount driven between charges.[16] In addition to fuel costs, other costs to be considered include depreciation and maintenance. As the City self-insures, any differential cost in insurances rates for these vehicles is not relevant.

In evaluating the environmental performance of plug-in electric vehicles such as the Volt, indirect pollution associated with the generation of electricity used to charge the vehicle's batteries should also be considered. Determining the carbon footprint of the Chevrolet Volt on a life cycle basis should take into account the source of the electricity used to charge the vehicle and whether it is from high-carbon fuels or from cleaner sources. The electric grid in New York City relies on natural gas (56%), nuclear (38%), other fossil fuels (5%). Therefore, a recent study found that the carbon footprint of a pure plug-in electric vehicle, or EV (similar to the Chevrolet Volt when operating in all-electric mode) driven and charged in New York City is lower than in parts of the country that rely mainly on higher-carbon coal for electricity.[17] According to this study, charging an EV in the New York City yields global warming emissions equivalent to that of a gasoline-powered vehicle achieving 74 mpg, better than the best hybrid.[18]

Chevrolet Volts (at $38,549)[19] or Ford Fusion Energi Plug-in Hybrids (at $30,680) would cost the City significantly more than a Toyota Prius (at $21,862), absent subsidies. As a public agency that does not pay income tax, DSNY is not eligible for the $7500 federal tax credit available to federal income tax payers per Volt for the first 200,000 vehicles sold. Accordingly, DSNY has used federal CMAQ grant funding to cover the incremental cost of the Volts and Fusion Energi Plug-in Hybrids over the cost of a Prius or Fusion. The price of Chevrolet Volts and Ford Fusion Energi Plug-in Hybrids is expected to decline as production efficiencies are realized. As for operational costs, at current rates, a conventional hybrid that is driven 10,000 miles annually (the average for a DSNY sedan) for 10 years (the useful vehicle life for a DSNY sedan) will require 192 gallons of gasoline per year at a cost of $1.45 per gallon, for a total of $2784 in fuel costs (excluding oil changes, etc). A Volt that is driven the same daily distances in pure electric mode (by not exceeding 35 miles per day) would in theory require no gasoline over

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[15] According to the manufacturer, the 2016 Volt will take regular gasoline instead of premium gasoline.

[16] One recent study noted that for short trips of under 16 miles, the 2013 Plug-in Prius cost less per mile than a 2012 Volt (based only on fuel or electric use), due to the Volt's heavier battery. Ray Iannuzzelli, *Cost Per Mile Comparison: 2012 Volt vs 2013 Prius Plug-In* (April 13, 2012), using electricity costs of $0.12/KWh and $3.79 for regular gasoline, and $4.00 for premium gasoline. http://gm-volt.com/2012/04/13/cost-per-mile-comparison-2012-volt-vs-2013-prius-plug-in. For trips between 16 and 65 miles, powering the Volt costs less per mile, and for trips over 65 miles, the Plug-In Prius has the fuel cost advantage over the Volt. *Id.* DSNY electricity and gasoline costs differ from these figures, with electricity about $0.15/KWh and gasoline $1.45/gallon as of February 2, 2015, but the study's basic conclusions appear valid for DSNY.

[17] Don Anair & Amine Mahmassani, *State of Charge, Electric Vehicles' Global Warming Emissions and Fuel-Cost Savings across the United States*, (Union of Concerned Scientists April 2012) Technical Appendix, p. 8, Table A.1, citing USEPA 2010a, and assuming an EV efficiency of a Nissan Leaf, 0.34kWh/mile.

[18] *Id*. at 17.

[19] The price is based on the City's FY2013 contract, since the Volt was not included in the City's FY2014 contract. The MSRP price for the Volt decreased by $5,000 since FY2013.

the 10 years, and save much of the $2784, minus the cost of electricity consumed (0.36 kWh/mile at $0.15/kWh), which comes to well under the equivalent cost of gasoline. Even so, however, over this period the Volt's savings in fuel would not compensate for the higher initial cost of the Volt, absent subsidies. (Even with the $7500 tax credit, various studies have noted that the cost premium for a Volt over a conventional hybrid will not be recovered by fuel savings over the life of the vehicle.[20]) As for durability, the battery life of a Volt is warrantied for 100,000 miles and 8 years, whichever comes first. The mileage would generally be adequate for the useful service life of a DSNY sedan, although failure after 8 years and prior to achieving 100,000 miles would be a disadvantage, given the substantial battery replacement cost for a Volt.

In determining which vehicles to purchase, DSNY evaluated the Volt's and Fusion Energi Plug-In Hybrid's and conventional hybrid's operational performance together with environmental considerations. DSNY has observed no significant difference in performance in the field between the Volt and the Prius or Fusion Hybrid. A Prius has more cargo space than a Volt and like the Fusion and Fusion Energi Plug-in Hybrid seats five, while the Volt seats only four, but these differences are not material for typical DSNY sedan operations. The requirement of charging the Volt and Fusion Energi Plug-in Hybrid creates certain operational issues not posed by the Prius or Fusion Hybrid, including a comparatively long charge time (about three hours at 240V), the limited number of parking spots with charging equipment at DSNY facilities, and the need for electrical upgrades at certain DSNY facilities to accommodate the required amperage for vehicle charging. The environmental benefits of operating a Volt or Fusion Energi Plug-in Hybrid over the Prius or Fusion Hybrid for DSNY's fleet (equivalent to 24 to 27 more mpg equivalent, with lower local emissions and lower carbon emissions) can only be obtained via an adequate infrastructure and flexibility in charging time.

The Department continues to assess the technological advances of hybrid electric vehicles and plug-in hybrid electric vehicles.

Zero Emission Vehicles

DSNY has also started purchasing zero emission all-electric vehicles for its fleet under the mandate of LL 38/2005. Zero emission vehicles have the potential to bring further benefits to local air quality, as well as fuel cost savings and greenhouse gas reduction, compared to DSNY's current hybrid fleet. The improvement over the Volt may be insignificant however, when DSNY sedan usage stays under 35 miles per day, as it generally does, so that the Volt operates primarily in electric mode, as noted above. Moreover, such all-electric vehicles require additional charging infrastructure, and may limit DSNY's operational flexibility for such sedans in winter emergency snow situations due to relatively slow charging times. In 2013, DSNY installed 18 Level 2 electric vehicle charging stations at DSNY garages throughout the five

[20] See, e.g., Ken Paulman, "Is the Chevy Volt Payback Really 26 Years?", *Midwest Energy News* (April 5, 2012) accessed at http://www.midwestenergynews.com/2012/04/05/is-the-chevy-volts-payback-period-really-26-years/.; Michelle Krebs, "Will Higher Gas Prices Boost EV, Hybrid Sales?", *Edmonds .com* (February 28. 2012) accessed at http://www.edmunds.com/industry-center/analysis/will-higher-gas-prices-boost-hybrid-ev-sales.html.; Nick Bunkley, "Payoff for Efficient Cars Takes Years" *New York Times* (April 4, 2012, accessed at http://www.nytimes.com/2012/04/05/business/energy-environment/for-hybrid-and-electric-cars-to-pay-off-owners-must-wait.html?_r=1.

boroughs. DSNY currently has 49 Level 2 electric vehicle charging stations citywide. In CY 2013, DSNY acquired 18 all-electric Nissan Leafs ($29,929) for light duty use. Their performance has been satisfactory.

DSNY also purchased and is testing two Ford Transit Connects (pure plug-in electric vans). In FY2010, DSNY put into service one Navistar eStar all electric Class 4 truck, which is currently being tested in fleet service. Its performance has been satisfactory so far.

DSNY intends to conduct further studies on the economic and operational feasibility of incorporating more alternative fuel sanitation vehicles into its fleet.

Testing of Biodiesel Blends

DSNY is further developing its clean air efforts by implementing advanced technologies to reduce emissions and utilizing clean diesel fuel with a renewable alternative biofuel component. For example, in March 2007, DSNY launched a biodiesel (B5) initiative citywide on all diesel-powered equipment (on-highway and off-highway), utilizing 5% biodiesel (made from soybeans) and 95% (petroleum-based) ULSD. To date, the B5 initiative resulted in no change in vehicle performance, no operator or mechanic complaints, no increase in down rate, and good winter operability. In August 2007, DSNY implemented its B20 (20% biodiesel) pilot study in the Queens 6 district and based on those encouraging results, in July 2010 DSNY expanded the study to the Brooklyn 5 district. In advance of the Local Law 73 of 2013 mandate to power all diesel fuel-powered motor vehicles owned or operated by the city of New York with at least B20 for the fiscal year beginning July 1, 2016 and thereafter between the months of April and November, DSNY expanded the pilot study citywide in CY 2013, for a total of 59 districts. Testing in all districts is on-going. B5 biodiesel costs about the same as standard ULSD, while B20 biodiesel costs somewhat more. DSNY plans to use B20 generally from April 15 through November 15 and B5 during the remainder of the year (colder weather). This yields a net reduction in carbon emissions of more than 10% compared to conventional fossil fuel diesel use.

Conclusion

As a result of DSNY's efforts, dramatic improvements in clean diesel technology, federal mandates for ultra-low sulfur diesel fuel, much stricter new vehicle emission standards, and local law BART requirements for pre-2007 trucks, DSNY has already cut its overall diesel fleet PM emissions by approximately 90% and NOx emissions by 81% since LL38/2005 was passed, with further reductions expected as the fleet turns over. Furthermore, in accordance with PlaNYC2030's goal of a 30% reduction below FY2005 levels by 2017, DSNY has already achieved a 10 to 20% reduction in greenhouse gas emissions from fleet operations, including a 50% reduction in light duty vehicle emissions.

DSNY will continue to participate in research and development of new technologies and to evaluate the mechanical reliability and operability of CNG and other alternative fuel collection trucks to assess their respective environmental and economic performances. DSNY is currently testing 13 diesel-powered hybrid-electric street sweepers in eight districts. DSNY is committed to exploring fully the costs and benefits of incorporating various advanced technologies into its

fleet. DSNY's B20 initiative citywide has met with positive results and testing is ongoing. This initiative has the potential to further reduce truck emissions, including greenhouse gases.

* * *

Appendix 1: DSNY CNG Fuel Street Sweepers as of January 1, 2015

VehicleID	VIN #	Vehicle Type	Make / Model
20CNG-602	1J9VM4L976C172002	Street Sweeper	Johnston 4000
20CNG-610	1J9VM4L966C172010	Street Sweeper	Johnston 4000
20CNG-703	1J9VM4L918C172113	Street Sweeper	Johnston 4000
20CNG-708	1J9VM4L908C172118	Street Sweeper	Johnston 4000
20CNG-709	1J9VM4L9X8C172109	Street Sweeper	Johnston 4000

Appendix 2: DSNY's CNG Collection Trucks

Vehicle ID	Make / Model	Vehicle Type	VIN #
24CNG-001	Crane Carrier LET2	Front Loading	1CYCCZ4848T048392
25CNG-501	Crane Carrier LET2	Rear Loading	1CYCCZ4868T048393
25CNG-502	Crane Carrier LET2	Rear Loading	1CYCCZ4868T048569
25CNG-503	Crane Carrier LET2	Rear Loading	1CYCCZ4828T048570
25CNG-504	Crane Carrier LET2	Rear Loading	1CYCCZ4848T048571
25CNG-505	Crane Carrier LET2	Rear Loading	1CYCCZ4868T048572
25CNG-506	Crane Carrier LET2	Rear Loading	1CYCCZ4888T048573
25CNG-507	Crane Carrier LET2	Rear Loading	1CYCCZ48X8T048574
25CNG-508	Crane Carrier LET2	Rear Loading	1CYCCZ4818T048575
25CNG-509	Crane Carrier LET2	Rear Loading	1CYCCZ4838T048576
25CNG-510	Crane Carrier LET2	Rear Loading	1CYCCZ4858T048577
25CNG-601	Crane Carrier LET2	Rear Loading	1CYCCZ4819T049419
25CNG-602	Crane Carrier LET2	Rear Loading	1CYCCZ4889T049420
25CNG-603	Crane Carrier LET2	Rear Loading	1CYCCZ48X9T049421
25CNG-604	Crane Carrier LET2	Rear Loading	1CYCCZ4819T049422
25CNG-605	Crane Carrier LET2	Rear Loading	1CYCCZ4839T049423
25CNG-606	Crane Carrier LET2	Rear Loading	1CYCCZ4859T049424
25CNG-607	Crane Carrier LET2	Rear Loading	1CYCCZ4879T049425
25CNG-608	Crane Carrier LET2	Rear Loading	1CYCCZ4899T049426
25CNG-609	Crane Carrier LET2	Rear Loading	1CYCCZ4809T049427
25CNG-701	Crane Carrier LET2	Rear Loading	1M2AU14C4DM001603
25CNG-702	Crane Carrier LET2	Rear Loading	1M2AU14C6DM001604
25CNG-703	Crane Carrier LET2	Rear Loading	1M2AU14C8DM001605
25CNG-721	Crane Carrier LET2	Rear Loading	1M2AU14C9DM001709
25CNG-722	Crane Carrier LET2	Rear Loading	1M2AU14C5DM001710
25CNG-723	Crane Carrier LET2	Rear Loading	1M2AU14C7DM001711
25CNG-724	Crane Carrier LET2	Rear Loading	1M2AU14C9DM001712
25CNG-725	Crane Carrier LET2	Rear Loading	1M2AU14C0DM001713
25CNG-726	Crane Carrier LET2	Rear Loading	1M2AU14C2DM001714
25CNG-727	Crane Carrier LET2	Rear Loading	1M2AU14C4DM001715
25CNG-728	Crane Carrier LET2	Rear Loading	1M2AU14C6DM001716
25CNG-729	Crane Carrier LET2	Rear Loading	1M2AU14C8DM001717
25CNG-730	Crane Carrier LET2	Rear Loading	1M2AU14CXDM001718
25CNG-731	Crane Carrier LET2	Rear Loading	1M2AU14C9DM001726
25CNG-732	Crane Carrier LET2	Rear Loading	1M2AU14C0DM001727

25CNG-733	Crane Carrier LET2	Rear Loading	1M2AU14C2DM001728
25CNG-734	Crane Carrier LET2	Rear Loading	1M2AU14C4DM001729
25CNG-735	Crane Carrier LET2	Rear Loading	1M2AU14C0DM001730
25CNG-736	Crane Carrier LET2	Rear Loading	1M2AU14C2DM001731
25CNG-737	Crane Carrier LET2	Rear Loading	1M2AU14C4DM001732
25CNG-738	Crane Carrier LET2	Rear Loading	1M2AU14C6DM001733
25CNG-739	Crane Carrier LET2	Rear Loading	1M2AU14C8DM001734
25CNG-740	Crane Carrier LET2	Rear Loading	1M2AU14CXDM001735
25XG-001	Crane Carrier LET2	Rear Loading	1CYCCZ48X9T049418

Appendix 3: DSNY's Hybrid Collection Trucks

Chassis Mfg	**Fuel**	**Hybrid Sys**	**Series/Parallel**	**# of Units in Service**
Crane Carrier Corp	Diesel	Electric	Parallel	3
Crane Carrier Corp	Diesel	Hydraulic	Parallel	2
Crane Carrier Corp	CNG	Hydraulic	Parallel	1
Mack	Diesel	Hydraulic	Parallel	49